Copy No.________

Defence Research and Development Canada
Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

# Maritime Concept Development Approach for a Force Protection In-Harbour Transit of a Canadian Patrol Frigate

## *Concept Screening and Selection for the MCD&E Process*

*Mark A. Gammon*

**Defence R&D Canada – Atlantic**

Technical Memorandum

DRDC Atlantic TM 2005-148

September 2005

Canada

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**SEP 2005** | 2. REPORT TYPE | 3. DATES COVERED<br>**-** |
| 4. TITLE AND SUBTITLE<br>**Maritime Concept Development Approach for a Force Protection In-Harbour Transit of a Canadian Patrol Frigate** | | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**Defence Research & Development Canada - Atlantic,PO Box 1012,Dartmouth Nova Scotia,CA,B2Y 3Z7** | | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | 10. SPONSOR/MONITOR’S ACRONYM(S)<br>11. SPONSOR/MONITOR’S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES
**The original document contains color images.**

14. ABSTRACT
**see report**

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | |
| **unclassified** | **unclassified** | **unclassified** | | **48** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

This page intentionally left blank.

# Maritime Concept Development Approach for a Force Protection In-Harbour Transit of a Canadian Patrol Frigate

*Concept Screening and Selection for the MCD&E Process*

Mark A. Gammon

**Defence R&D Canada — Atlantic**

Technical Memorandum

DRDC Atlantic TM 2005-148

September 2005

Author

Mark A. Gammon

Defence Scientist

Approved by

James L. Kennedy

Chief Scientist

Approved for release by

Kirk Foster

DRP Chair

## Abstract

Maritime Concept Development and Experimentation (CD&E) is being implemented to facilitate development of innovative concepts and rapid prototyping of solutions to advance maritime capabilities and fill capability gaps. Concept development is applied to the problem of an in-harbour transit scenario for a Canadian Patrol Frigate (CPF). The objective is to explore the CD&E process through the use of a current issue. The scenario represents a hypothetical ship deployment versus an asymmetric threat of a small craft surface terrorist attack. The nature of the threat means that unconventional solutions are required. As an initial approach, the use of group decision-making methodologies is tested for generating and screening concepts. The lessons learned provide initial observations of the CD&E process as well as insights for this scenario.

## Résumé

Le CD&E maritime est mis en application pour faciliter le développement des concepts innovateurs et le ‘prototypage’ rapide des solutions afin d’augmenter les possibilités maritimes et de combler les lacunes de celles-ci. Le développement de concept est appliqué au problème d'un scénario de passage dans un port pour une frégate de patrouille canadienne (CPF). L'objectif est d'explorer le processus de développement et d'expérimentation de concept (CD&E) par le biais d'une question actuelle. Le scénario représente un déploiement hypothétique de navires face à une menace asymétrique d'une attaque terroriste de la part d’un appareil de surface. La nature de la menace exige des solutions non conventionnelle de rechange appropriées. Comme première approche, l'utilisation de méthodologies de prise de décision de groupe est testée en vue de la production et de l’examen des concepts. Les leçons retenues fournissent quelques observations initiales du processus de CD&E ainsi qu'une certaine manière potentielle de représentation dépassant le scénario donné.

This page intentionally left blank.

# Executive summary


**Introduction**

The Canadian Forces Maritime Warfare Centre (CFMWC) has established a maritime Concept Development and Experimentation (CD&E) capability to aid in development of defence solutions within the rapidly changing security environment. The purpose of this study was to determine how the generation, selection and screening of concepts could be undertaken as part of a CD&E methodology. A force protection problem concerning a CPF against a small craft attack was investigated. A workshop was held at CFMWC and a group consensus decision-making approach was utilized. Detailed concept development was demonstrated to further highlight the CD&E process.

**Results**

Three decision-making methodologies for ranking concepts were utilized. During the workshop, participants were separated into two groups and additional concepts were formulated. The group approach provided a vehicle for discussion of ideas. A sensitivity analysis of selected results using one of the methodologies showed how the weightings affected the ranking of concepts applied to the selection criteria.

**Significance**

The CD&E capability at the CFMWC can have a significant impact by rapidly prototyping solutions and concepts for current capability gaps. The object is to reduce the time required to introduce new capability into service. The current study demonstrates that a team approach in a resource-constrained environment can well identify likely concepts for focused study.



Gammon, M.A. 2005. Maritime Concept Development Approach for a Force Protection In-Harbour Transit of a Canadian Patrol Frigate. DRDC Atlantic TM 2005-148, Defence R&D Canada — Atlantic.

# Sommaire


**Introduction**

Pour soutenir l'établissement des possibilités maritimes de développement et d'expérimentation de concept (CD&E) au Centre de guerre maritime des Forces canadiennes (CFMWC), on a étudie le problème de la protection de la force d'un CPF en transit dans un port face a une attaque de petits appareils. Le but était de déterminer comment la production, le choix et le criblage des concepts pourraient être entrepris et de définir la méthodologie du CD&E. Pour un examen du concept initial, un atelier était tenu à CFMWC dans lequel une approche de prise de décision de consensus de groupe a été établie en utilisant trois méthodes différentes. Les concepts admis qui en résultaient ont été alors élabores en vue du  développement détail de concept par un examen plus détaillé du scénario.

**Résultats**

Un accord significatif a été obtenu par les trois méthodologies de prise de décision. En plus des concepts de criblage, deux groupes séparés ont produit un concept additionnel. Ce concept était une combinaison de certains des concepts admis. Alors que le criblage des concepts employant l'approche de groupe est naturellement subjectif, une analyse de sensibilité employant des pondérations altératives des critères de criblage a prouvé que les gradations qui en résultaient étaient en grande partie inchangées. Une certaine modélisation et simulation des concepts étaient menées en montrant que l'efficacité des concepts était en grande partie sujette au retard dans la classification de la menace suivie de l'exécution des concepts pour réduire la vitesse de progression de la menace.

**Signification**

Les possibilités de CD&E au CFMWC peuvent avoir un impact significatif par le ‘prototypage’ rapide des solutions et des concepts en vue de combler les lacunes des possibilités actuelles. Les méthodes courantes peuvent fournir une approche d'équipe dans un environnement caractérise par des contraintes de ressources pour identifier les concepts probables des études plus focalisées.



Gammon, M.A. 2005. Approche maritime de développement de concept pour un passage de Dans-Port de protection de force d'une frégate canadienne de patrouille. DRDC Atlantic TM 2005-148, Defence R&D Canada — Atlantic.

# Table of contents

Abstract ..... i

Executive summary ..... iii

Sommaire ..... iv

Table of contents ..... v

List of figures ..... vii

Acknowledgements ..... viii

1. Introduction ..... 1
   - 1.1 Maritime Concept Development and Experimentation ..... 2
   - 1.2 Purpose ..... 3

2. Force Protection Example ..... 5
   - 2.1 Scenario ..... 5
   - 2.2 Concepts ..... 7
   - 2.3 Criteria ..... 11

3. Concept Screening ..... 13
   - 3.1 Concept Selection Matrix ..... 13
   - 3.2 TETRA Evaluation ..... 15
   - 3.3 MARCUS Evaluation ..... 16
   - 3.4 Group Consensus Results by Discussion ..... 17
   - 3.5 CPF FP In-Harbour Transit Concept Selection ..... 19

4. Summary and Conclusions ..... 20

5. References ..... 21

Annex A. TETRA Quick Start Guide ..... 23

Annex B. MARCUS Presentation ..... 24

This page intentionally left blank.

## List of figures

Figure 1. Maritime Concept Development and Experimentation Process.................................. 2

Figure 2. Halifax Harbour Departure Scenario for a CPF ........................................................ 6

Figure 3. In-Harbour Transit Scenario with a Small Surface Craft Threat................................ 7

Figure 4. Unmanned Sea Surface Vehicle (USSV) ................................................................... 9

Figure 5. Armed Rigid Hull Inflatable Boat (RHIB) – Manned or Unmanned.......................... 9

Figure 6. Posted Sentries for On-Board Maritime Deployment .............................................. 10

Figure 7. Small Patrol Craft used as Force Protection Augmenters ........................................ 10

Figure 8. Floating Barriers using Buoys and Hawsers ............................................................ 11

Figure 9. Manned Stand-off Missile System ........................................................................... 11

Figure 10. Example Concept Selection Matrix......................................................................... 14

Figure 11. Average Ratings for Force Protection Concepts ..................................................... 14

Figure 12. Tetra Single Decision Maker Program GUI........................................................... 15

Figure 13. Tetra Results of Force Protection Concepts ........................................................... 16

Figure 14. Tetra Results with Different Criteria Weighting Schemes...................................... 18

Figure 15. CPF Force Protection In-harbour Transit Concept Selection.................................. 19

## List of tables

Table 1. Weighting Schemes ..................................................................................................... 18

# Acknowledgements

The author would like to acknowledge the assistance of Canadian Maritime Warfare Centre (CFMWC) and the encouragement provided by Deputy Commanding Officer, L.Col. Tom Sand.  The input and feedback from participants at the MCD&E workshop was very welcome.  The assistance of DRDC Atlantic staff for preparation of this document and in particular the commentary provided by the Chief Scientist, Dr. James L. Kennedy is highly appreciated.

# 1. Introduction

The Operational Research (OR) team at Defence Research and Development Canada - Atlantic is supporting the establishment of a Maritime Concept Development and Experimentation (MCD&E) capability at the Canadian Forces Maritime Warfare Centre (CFMWC). The impetus for CD&E comes from the requirement to provide more capability-based planning [1] and concept development is viewed as one of the means to implement this approach. The goal is to reduce the time requirement to introduce new capability into service.

The governance and organizational structure for the CD&E capability was described in a report on implementation [2]. In addition, the establishment of a Maritime CD&E working group has provided input to the CD&E capability. The role of OR in concept-lead long-range planning is outlined in [3]. The application of a scientific approach in the form of OR to problems that involve human and operational aspects in conjunction with technical issues is seen as a way of improving decisions[1], providing optimal application of resources and gaining insights on the operational effectiveness of solutions for the military. This follows the aims as stated in [1] to "determine the right blend of plans, people, equipment and activity to optimize the capacity of the DND/CF to fill its assigned roles"[2].

The role of CD&E in the capability based planning paradigm is to bring together a mix of people and tools to tackle problems at a creative level. The core of the process is to use a team approach for generating, selecting, and developing the most promising concepts. The team should consist of military, OR and possibly other scientific, engineering, modelling and simulation personnel. Resource constraints and the requirement to multi-task means that the availability of personnel will likely be through a flexible assignment of tasks rather than more traditional dedicated project teams.

As a result of these resource limitations, one of the methodologies being explored for the initial generation and screening of concepts is to use a group consensus decision-making approach. The advantages of this approach are that the amount of time required for the group or "team' to commit resources to a problem will be reduced. The use of a group for brainstorming follows naturally as a concept generation method to obtain innovative ideas. The composition of the group can be partially experts but additionally from other, defence related backgrounds, such that the potential for more ideas can be maximized.

The disadvantages of this approach are related to the subjectivity of a group consensus. Methodologies for group consensus decision-making rely on input from the participants to determine the values associated with the criteria being used to rate the concepts. These are naturally subjective and therefore subject to question. The purpose of evaluating a

[1] Quoted from Argell, P.S. "Operational Research at the National defence Research Institute of Sweden, Omega, Vol. 13 No.2, pg. 121-124, 1985.
[2] Vice Chief of Defence Staff (VCDS) capability-based planning definition from the DND/CF Concept Paper on Creating the CF of 2020.

concept relative to some criteria through a group consensus approach is to screen concepts and determine the likely candidates for detailed concept development. The candidates that are selected can be put forward for detailed concept development. The detailed concept development stage would then try to determine more quantitative assessments of favourable concepts. Finally the most likely concept (or concepts) would be selected for experimentation.

As one of the action items of the inaugural meeting of the maritime CD&E working group [4], a project proposal was put forward to address an issue that would be of current interest to the Canadian Navy [5]. The project would involve the development of a scenario, the generation of concepts, the establishment of criteria and the screening of concepts. The evaluation of the concepts would be conducted using a group consensus decision-making approach. Although the objective is to determine the feasibility of this approach for the initial stages of CD&E, the results of the process should provide some insight and merit to providing solutions for the problem.

## 1.1 Maritime Concept Development and Experimentation

The maritime CD&E process can be viewed as in Figure 1. Concepts are generated in response to capability gaps. Capability gaps or capability requirements may not, however, be well defined. Other useful drivers may include the Maritime Operations Deficiency List (MODL), and specific directives or projects from other force planning or force development directorates. Another model exists which was discussed at the Maritime CD&E WG on “technology push” versus “capability pull” as the CD&E drivers. Technology push is the process whereby developments in technology, disruptive or otherwise, may provide significant incentive for development. The impact of technology push is not discussed in this report.

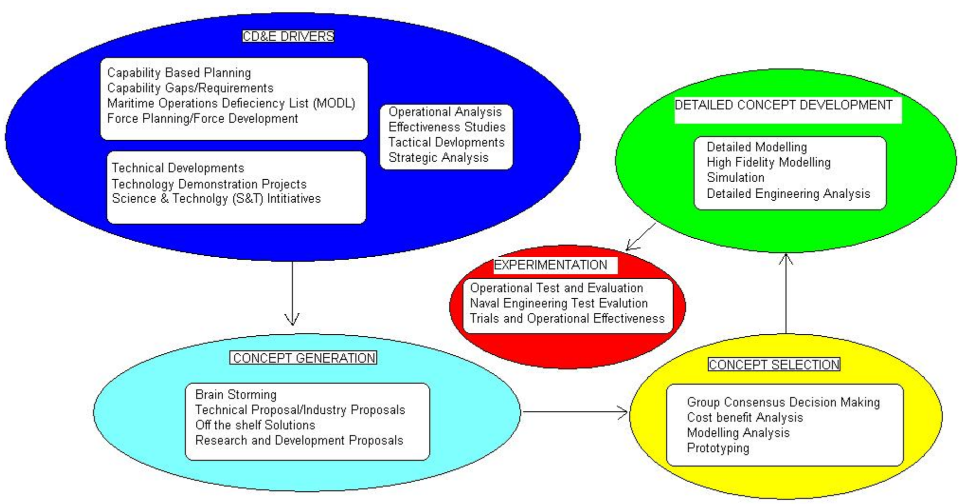



***Figure 1.*** *Maritime Concept Development and Experimentation Process*

Although not a driver *per se*, studies related to operations and in particular OR studies, tactical development studies, and strategic analysis studies may highlight areas for potential development. These may feed into the CD&E process by generating new capability requirements or visualizing new areas of opportunity. As the CFMWC will be responsible for near term problems, the solutions or concepts generated will probably include off the shelf solutions or ideas having shorter development times. Concepts can be generated in brainstorming sessions, be obtained from research and industry proposals, or be suggested from other departments and directorates. However a formal concept generation process has yet to be defined.

In order to aid the development of a concept generation capability, the use of a decision-making group consensus approach is tested for screening and selecting concepts as well as to generate ideas. Once the favourable candidates are selected by consensus, further cost-benefit and modelling may derive a short list of candidates to be the subject of detailed analysis. Detailed analysis may encompass more OR studies, Computer Aided Engineering (CAE) for development, and R&D. Industry proposals can be a significant contribution, as the solutions will be developed in the near term of 0-5 years. Tactical development may commence and modelling and simulation in particular will be the focus at this stage.

Following detailed concept development, the final phase of the CD&E process for experimentation involves trials, exercises and demonstrations. The emphasis is to demonstrate effectiveness and determine if the solutions are able to meet the expected result. Due to the nature of experimentation, a number of guides [6,7] have been developed to assist in the experiment. An experimentation guide for Maritime CD&E is also being planned. It should be noted that concepts may not require detailed concept development and may lead directly to experimentation, subject to a well-defined plan, especially if the concept utilizes Commercial Off-the-Shelf (COTS) equipment or resources.

## 1.2 Purpose

The purpose of this report is primarily to provide results of the workshop held at CFMWC on CD&E, with the focus being the Force Protection Above Water Warfare (AWW) scenario proposed at the MCD&E WG meeting. The workshop was held to investigate the validity of using a group consensus decision-making approach for concept screening. Three different methods of analysis were used. The first uses a simple matrix of alternatives and criteria in an Excel worksheet. The second uses a utility-based theory [21] and software known as TETRA (see annex A). The third utilizes a Centre for Operational Research and Analysis (CORA) in-house method and software called MARCUS (see annex B). The aim is to determine the usefulness of the decision-making approach, gain experience and lessons learned while forging a new process for the conduct of CD&E. In addition the project would attempt to define some favourable alternative concepts towards the current operational FP issue in order to highlight the capability of CD&E to tackle problems that are within the given time horizon of 0-5 years. In order to select and analyze these concepts it will be necessary to identify tools for initial concept selection and screening, and to determine means for conducting

detailed concept development, principally through the use of models and simulations. The use of appropriate models and simulations is a fundamental requirement for progressing the establishment of an MCD&E capability at CFMWC.

# 2. Force Protection Example

To further define and refine the CD&E process a Maritime Force Protection issue is used to generate and select concepts. The scenario is described first. The scenario briefly examines a hypothetical naval asymmetric threat event inside Canadian waters. As the threat is asymmetrical and the constraints problematic, there is a potential for using unorthodox solutions. The criteria used to evaluate the concepts include performance of the proposed system or concept and other “show-stopper” constraints such as cost, technical risk and the ability or likelihood of the solution to be deployed. The scenario is described first, followed by the criteria that were used for evaluation. The methodologies and evaluations are described in the next section.

## 2.1 Scenario

The scenario is based on the assumption that a ship at sea has defensive systems that can be utilized when in operation. In port where these may be restricted, the ship may be provided some protection by guarded dockyard facilities and initiatives to provide port protection. This has been the subject of recent OR studies [8,9,10]. In addition, studies were conducted on the capabilities of a ship versus a surface attack and against a swarm of small craft [11,12,13]. However the ship in-transit while exiting or entering port is constrained in the use of conventional defensive systems because of proximity to land and the potential for collateral damage. Ship effectiveness in terms of the gun effectiveness and standoff distances can be measured against the threat as a best-case scenario.

Operation Scenario. The scenario is depicted as follows: A Canadian Patrol Frigate (CPF) leaves Halifax dockyard en-route to joining a NATO Task Group that is being assigned the task to patrol the Atlantic seaboard. Before leaving the dock, a RIB or RHIB (Rigid hull Inflatable Boat) is deployed to act in an interdiction/exclusion zone while the ship is in harbour. It will accompany the ship past Sambro. The CPF is to transit from the dock through the harbour and approaches as depicted in Figure 2.

Threat Scenario. The threat is a small craft that contains explosive. The type of craft is assumed to be a converted fishing boat that has been acquired by some means. The aim of the attacking vessel is to cause extensive damage to a warship, which is in this case a CPF. The port of Halifax is chosen as a potential target based on a perception of a lower level of security and a higher probability of remaining covert. The small craft may be remotely piloted from a hidden vantage point.

The intercept strategy and route is to wait until the CPF is in view and then deploy the boat. The tactic is to load the vessel with enough explosive to cause major damage if exploded near the CPF using a remote detonator. At approximately 0800 the CPF gets underway and transits from the dock past the waterfront. At approximately 0830 it becomes visible by the covert observers at Purcell’s Cove. At that time the boat gets underway and exits Purcell’s cove with the intention of intercepting the CPF about midway along McNab’s island. The CPF is transiting in the harbour at about 8 knots, and will speed up to about 12 knots as it is going out past McNabs Island. The harbour has an

open speed limit, but normal transit speeds are between 8-12 knots[3]. The fishing boat can make a top speed of 10 knots, while the CPF can do 30+ knots. The RIB can manoeuvre upwards of 30+ knots.

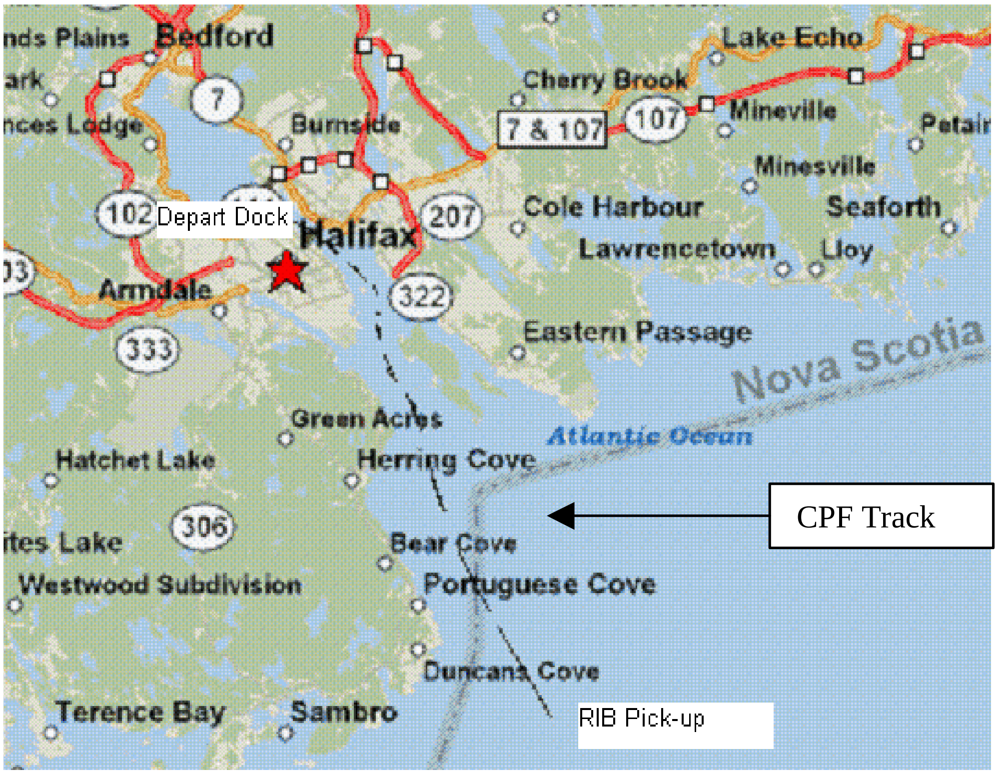



***Figure 2.** Halifax Harbour Departure Scenario for a CPF*

Given the transit speed of the CPF, it will take about 12-13 minutes to get to the intersection point where it will speed up to 12 knots. Meanwhile, the fishing boat exits Purcell's cove at 10 knots and matches a steady relative collision bearing so as to meet at the intersection point. The distances for each vessel are approximately the same, as shown in Figure 3, with about two kilometres to the intercept point. Factors that need to be considered are the delay required to identify that the boat is on a collision course, and the time needed to dispatch the RIB to intercept. It can be assumed that if the RIB intercepts the boat it will positively identify it as a threat.

[3] Discussion held with the Naval Liaison Officer (NLO), DRDC Atlantic, on transit speeds in harbour.

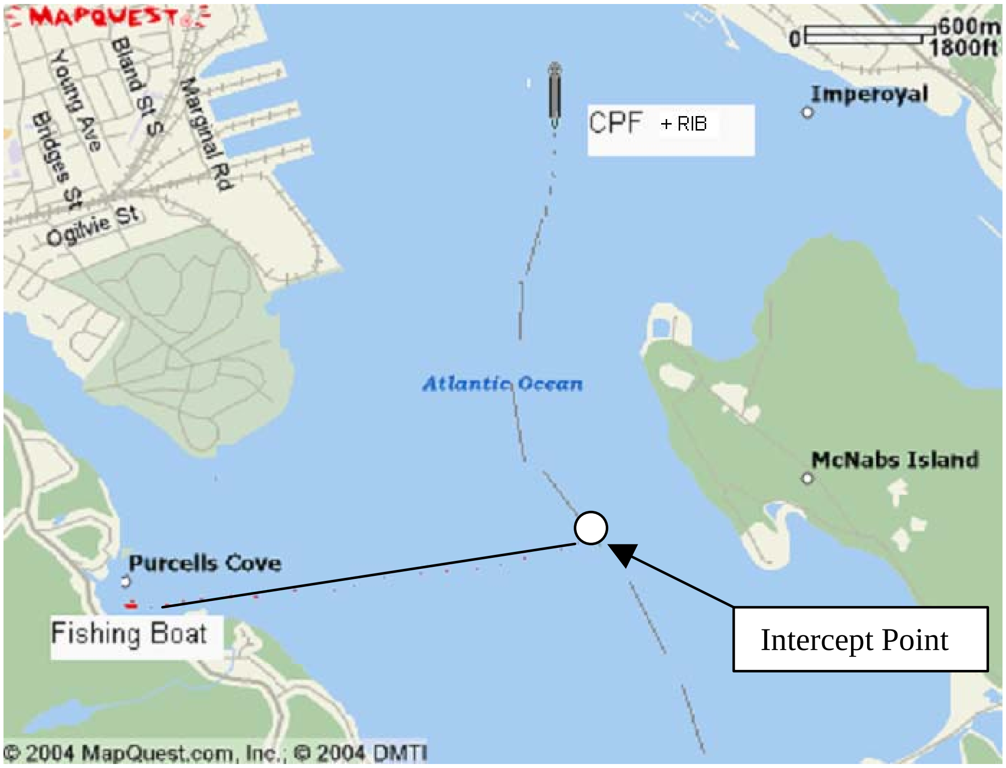



***Figure 3.*** *In-Harbour Transit Scenario with a Small Surface Craft Threat*

## 2.2 Concepts

The concepts used for this scenario were mainly the product of discussion with CFMWC for the given problem. As such they do not represent an investigation into the concept generation process or on tools that can be used for concept development [14]. In general a more thorough study and a formal procedure for concept generation may be implemented. An experiment to generate concepts through group discussion was incorporated into the group evaluation.

Concept generation has been discussed in terms of the governance for CD&E in a draft Maritime Command Order [15]. It describes the authority for the maritime CD&E process and a CF procedure that is being established with regard to how concepts are collected and screened, according to criteria established by the CD&E Coordinating Group. This body will also prioritize activities and set objectives for a CD&E program. A subordinate body, the MCD&E working group, will allocate resources and staff towards the CD&E program. The CD&E program will be approved and reviewed yearly.

A CD&E work program is not currently available, and the procedures are still being established. The force protection scenario was developed for the purpose of testing the conduct of CD&E, and a list of concepts was established. The use of the group consensus decision making approach described in the next section may be of more utility at the coordinating group level for establishing the prioritized work program. It should be noted that this approach might additionally use collaborative techniques as mentioned in [2]

being developed by other agencies such as DRDC Ottawa under the CapDEM project [16,17].

The concepts that are used here are either under development or are potentially feasible by using equipment and resources that are readily available. These should satisfy the requirement that the solutions exist in the near term. However the concepts have different levels of development and technical risk and are evaluated accordingly. Pre-screening criteria should be conducted to determine whether the concepts are within the required time horizon.

The following concepts were initially considered:

a. Unmanned Sea Surface Vehicles (USSVs);

b. Armed Rigid Hull Inflatable Boats (RHIBs);

c. Patrol Boats;

d. Posted Sentries aboard Ship;

e. Standoff Weapon System; and

f. Towed Floating Barrier.

Two additional concepts were generated during a concept generation session that will be described later. The concept generation session used two separate groups of participants and consisted of both military personnel and defence scientists in each group. Their task was to derive at least one additional concept to add to the list through a brainstorming session. The session was intentionally kept short to emphasize concept generation and to reduce critical analysis of the different ideas. By discussion, each group independently agreed on a layered defence concept.

The first group used the list of available concepts and determined that a layer of favorable concepts would prove most effective. The layer consisted of using RIBs along with patrol boats, and having armed sentries on the ships. Air support was added in the form of Unmanned Air Vehicles (UAVs). The second group determined a very similar concept, using a layered defence but providing air support through the use of helicopters. The two additional concepts are then as follows:

g. Layered Defence-In-Depth: a combination of Armed RHIBs, Posted Sentries, Patrol Boats and an Unmanned Air Vehicle (UAV); and

h. Same as previous but using a manned helicopter instead of a UAV.

For the purpose of the concept screening, a brief description of the concepts was given to the participants. These are described next.

**Unmanned Sea Surface Vehicles (USSVs)**. This concept shown in Figure 4 is the surface equivalent of a UAV. The NAVSEA warfare centre in the US has developed

variants of USSVs that are 39 foot, 9-ton boats with top speeds of about 23 knots [18]. The basic idea is to use them as an unmanned boat that can be used to intercept (possibly ram) insurgents or at least have sensors onboard which can be operated remotely to observe approaching small craft.  One significant advantage is that the risk to human life by positioning the USSV near the incoming threat is reduced in the event of a premature explosion of an Improvised Explosive Device (IED).

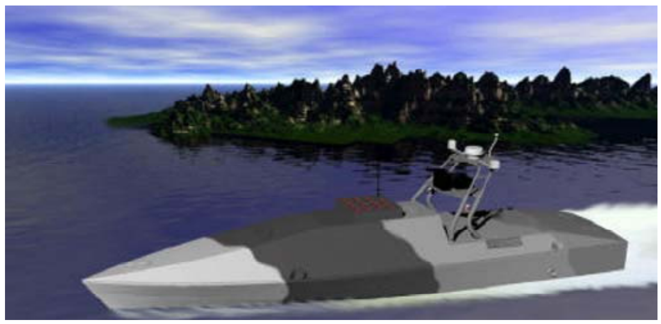


***Figure 4.*** *Unmanned Sea Surface Vehicle (USSV)*

**Armed RHIBs**.  These would be used in accordance with some standard interdiction procedures for using Rigid (Hull) Inflatable Boats (RIBs or RHIBs), where augmented RHIBs having more firepower, perhaps a 0.50 calibre machine gun, would patrol in number around the ship.  The activity of having RHIBs on active patrol might dissuade would be perpetrators. RHIBs can provide a fast interdiction capability.  The idea of an unmanned RHIB is also being promoted in the US as shown in Figure 5.

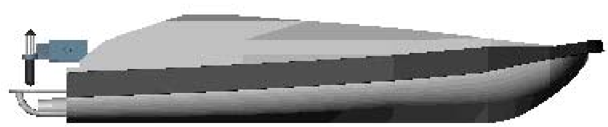


***Figure 5.*** *Armed Rigid Hull Inflatable Boat (RHIB) – Manned or Unmanned*

**Posted Sentries**.  This concept consists of armed sentries, posted around the ship to provide a defensive capability against an attack that could not be handled by the other weapon systems on board the ship.  CPFs currently have 0.50 calibre machine guns. Sentries could have other armament including grenade, or possibly, rocket launchers.  For more lethality the upgrade from a 0.50 calibre heavy machine gun to a Mark 38 shown in Figure 6 or a Mark 242 gun as is an alternative.

***Figure 6.*** *Posted Sentries for On-Board Maritime Deployment*

**Patrol Boats**. These are fully armed patrol boats of perhaps 15 meters or less in length that would run interdictions, have high speed, are manned by 3 or more personnel and could be used for other purposes besides Force Protection. Equipment might consist of a gun plus other weapons, and also contain surveillance equipment. The ABCO 32 recently acquired by the military is shown in Figure 7.

***Figure 7.*** *Small Patrol Craft used as Force Protection Augmenters*

**Towed Floating Barrier**. In order to provide a mobile barrier system, patrol boats (or other harbour craft) could deploy a barrier that would be towed behind the boat. This would probably require that the speed of the CPF and consort would be reduced in order for the barrier to be maintained. The barrier could be a simple system of buoys as shown in Figure 8 and hawsers that could impede or stop the progress of a small vessel.

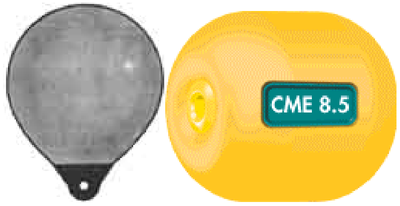



***Figure 8.*** *Floating Barriers using Buoys and Hawsers*

**Standoff Weapon System**. Although not quite in the purview of the time frame being examined, a standoff weapon system, either lethal or non-lethal, is another possible concept. A standoff weapon system might be similar to a grenade launcher, which could be autonomous or manned. It would provide a short-range weapon capability (less than 2000 metres) to be used as a defensive weapon against small craft. Figure 9 shows a standoff missile system.

***Figure 9.*** *Manned Stand-off Missile System*

## 2.3 Criteria

Each of the concepts was evaluated against a list of criteria. The criteria represented major factors that would need to be satisfied in order for the concept to have a chance of success. Criteria were not rigorously defined at this level of assessment, as the criteria were required to be simple and broad in context. A discussion about the evaluation using criteria is provided in the next section. Each criterion is described briefly.

**Overall Cost**. Costs can include capital cost, research and development cost, operational cost including personnel, and maintenance. The cost of each alternative is a significant aspect to the overall acceptability of a concept. The evaluation of cost at this level is not quantitative but is relative to each concept. A concept may still be affordable even though it is more expensive if it delivers a higher system capability.

**Deployment**. Each concept should have some level of deployment ability. The deployment ability may include the time to put into service, the ability of the ship to deploy the concept, and the difficulties in integrating it with current operations.

**Technical Risk**. In most concepts, some risk is necessary to engineer the concept. For the concepts that require little engineering, the risk may be low. For those concepts requiring advanced engineering the risk could be medium, while if significant engineering is required, the risk could be high.

**Development**. Development is defined as a progression from a simpler or lower to a more advanced, mature, or complex form or stage. Technical development refers to the process of conducting research and development. For the given short time frame, R&D should be appropriately limited but may still be required.

**Performance**. Since the objective in this Force Protection scenario is to guard against small craft approaching the ship and ultimately exploding beside the ship, one possible criterion is the ability of the concept to mitigate any blast. If the attacking craft can be kept clear of the ship the rating in performance could be high. If the attacking craft can approach near enough to the ship to cause damage when using an IED in a majority of cases then the rating would be low.

Criteria were selected based on the particular problem being addressed and specific projects have specific criteria. However the above criteria are general and the basic elements will likely reoccur in other maritime CD&E problems. Cost is one example of a criterion that is likely to be considered for most concepts. Risk, whether technical or another type of project risk, is a common element that decision makers will have to consider.

# 3. Concept Screening

In order to progress the CD&E process, a method to select and screen concepts was required to facilitate the use of detailed concept development following the selection of favoured concepts. Group decision-making methodologies are being investigated by various researchers [for example, see 19, 20].

Issues relating to concept evaluation lie at the core of the complete approach to doing this type of analysis. How does one evaluate concepts when the concepts themselves may lack definition of a rigorous nature? Should each concept be developed to the point where some analysis can be conducted, as when developing a warship or other type of vessel? If the concept is new then it may lack any previous experiential database that could be used to evolve it. Should judgments be collected by survey and will they be definitive?

The purpose of conducting a poll or survey is to capture, in some form, the preference structure of decision makers (DM) in order to solve a Multiple Criteria Decision Making (MCDM) problems. MCDM represents a broad field of study. For the purpose of CD&E, the use of some type of method to solve an MCDM type of problem should be considered as part of the concept selection process. In the past, various methods have been tried within the OR community of DND to obtain polls, with various degrees of success. Experience shows that the use of surveys can have an adverse effect due to the problems associated with both obtaining the data, i.e. the input from the different surveys, and the negative reaction to “form-filling”.

The group decision-making approach was tested to determine the process as applied to maritime CD&E and investigate the validity and applicability of this approach. A workshop was held at CFMWC January 14$^{th}$, 2005 to investigate the validity of using a group consensus decision-making approach for concept screening. Three different methods of analysis were used. The first is a simple concept selection matrix that is described in the next sub-section. The second uses a utility-based theory and software known as TETRA. The third utilizes a CORA in-house method and software called MARCUS.

## 3.1 Concept Selection Matrix

Of the numerous methods available, the simplest consists of a matrix of criteria and alternatives. A survey of opinion based on the participants’ reaction to alternatives under selection criteria is common to all methodologies. The criteria used were provided to the participants. For a simple matrix the evaluation of the concepts was rated from 1-5. The highest value 5 represents the most utility or score. For each concept these are summed. For the group exercise, conducted for the previous example, the criteria were assumed to be equally important. In the example shown in Figure 10, the priorities are assumed to be equal. In this case, each criterion’s rating (using a rating system between 1-5) is simply added to give a total score for each alternative.

***MCD&E Force Protection Workshop***
***Participant X***

| | | | ***CRITERIA*** | | | | |
|---|---|---|---|---|---|---|---|
| ***CONCEPTS*** | ***OVERALL COST*** | ***DEPLOYMENT*** | ***TECHNICAL RISK*** | ***DEVELOPMENT*** | ***PERFORMANCE*** | ***TOTAL*** | ***rank*** |
| | ***Rating**** | ***Rating**** | ***Rating**** | ***Rating**** | ***Rating**** | ***Rating**** | |
| Unmanned Seas Surface Vehicles (USSV) | 1 | 2 | 3 | 3 | 4 | 13 | 7 |
| Armed Rigid Hull Inflatable Boats (RHIBs) | 5 | 5 | 5 | 5 | 4 | 24 | 1 |
| Patrol Boats | 4 | 5 | 5 | 5 | 4 | 23 | 2 |
| Posted Sentries - Shipboard | 5 | 5 | 5 | 5 | 1 | 21 | 3 |
| Stand-off Weapon System | 4 | 3 | 5 | 4 | 2 | 18 | 5 |
| Layered Defence - UAV | 3 | 4 | 3 | 3 | 3 | 16 | 6 |
| Layered Defence - Helicopter | 3 | 5 | 4 | 4 | 3 | 19 | 4 |

***** Rates are based on Low value (1) to High value (5).***

| ***Low*** | ***Nominal*** | ***Medium*** | ***Moderate*** | ***High*** |
|---|---|---|---|---|
| ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |

***Figure 10**. Example Concept Selection Matrix*

The results of the surveys conducted during the CD&E workshop are shown in Figure 11. These represent the average ratings among the participants. The error bars represent the standard deviation in the results from six of the participants. As can be seen, the armed RHIB, patrol craft and posted sentries are nearly the same. The stand off weapon and layered defence combination with the helicopter also lie within the standard deviation of the top ranking concepts. The participants did not rate the towed barrier with this method as during the workshop it was replaced on the survey form by the additional layered defence concepts.

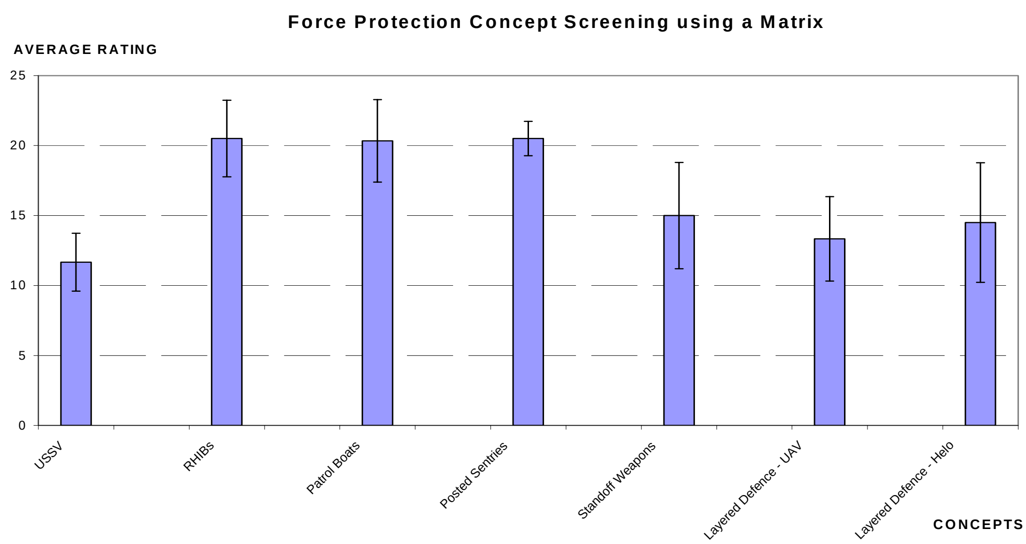



***Figure 11.** Average Ratings for Force Protection Concepts*

## 3.2 TETRA Evaluation

TETRA is commercially available software that employs utility theory [21]. Alternative solutions, or the equivalent of concepts are rated according to the same list of criteria. In TETRA, weights could be used to incorporate the preferences of the participants for the criteria. As the criteria were assumed to be equally preferable this function was not utilized. An example of the program window is shown in Figure 12. Note that the rating scale is a sliding scale from 0-100, which increases the ability of the user to distinguish between alternatives. In the simple matrix, the difference in ratings was from 1-5. The utility based method uses non-dimensional ratings based on verbal definitions of the upper and lower bounds for each criteria. By using non-dimensional the ratings, the mathematical foundation for adding ratings from different criteria is said to be more rigorous than in the simple matrix case, where each criteria are treated the same. The definition of the upper and lower bounds are still subjective as in any approach using group decision-making.

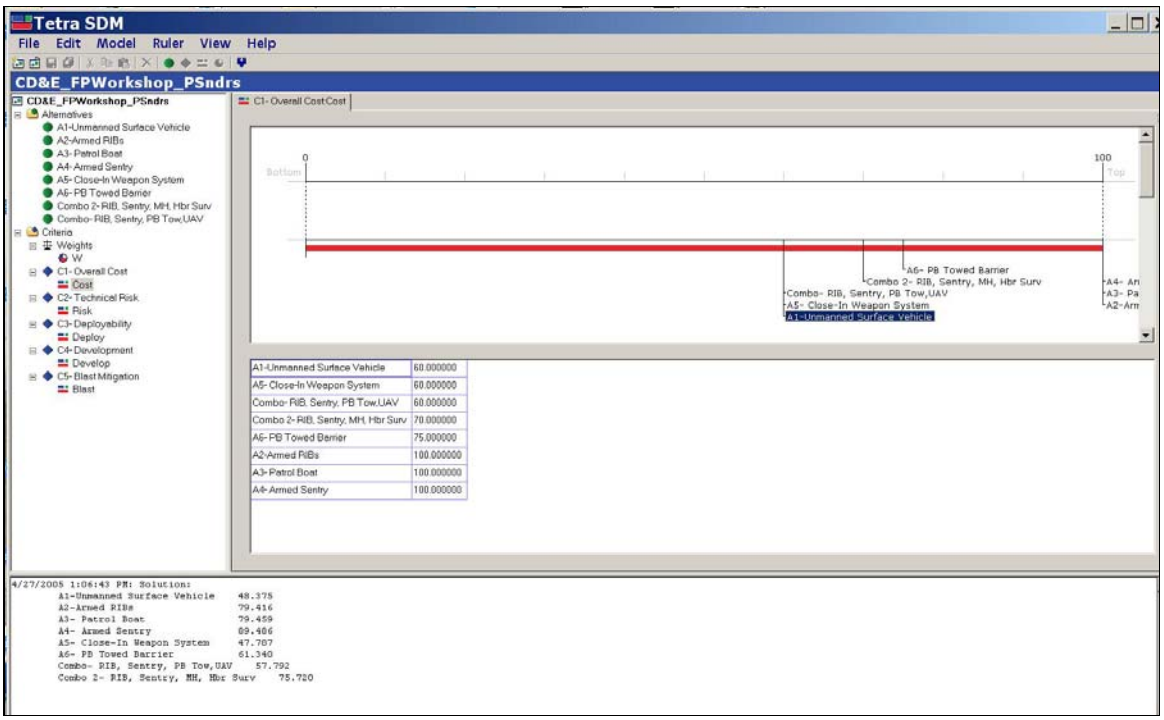



***Figure 12.*** *Tetra Single Decision Maker Program GUI*

The evaluation using Tetra was conducted at the workshop by taking a separate survey from the participants using the sliding scale. Tetra results are rated from 0-100 where 100 represents full utility as defined by the upper bound in each criterion and 0 represents none as defined by the lower bound. Besides the facility afforded by having the calculation built into the software, Tetra offers network utilities to allow the co-

coordinator and participants to be in a distributed system. The advantage of this approach was not investigated as the participants were all at the same workshop.

The result of averaging each of the participants ranking using Tetra is shown in Figure 13. The top three concepts are the armed RHIB and posted sentries, along with a towed barrier. The patrol boat is fourth which indicates that this concept has merit. The 5th ranking is both the standoff weapon system and the layered defence concept using a helicopter, as they are nearly equal. The USSV is ranked last after the layered defence concept using the UAV.

.

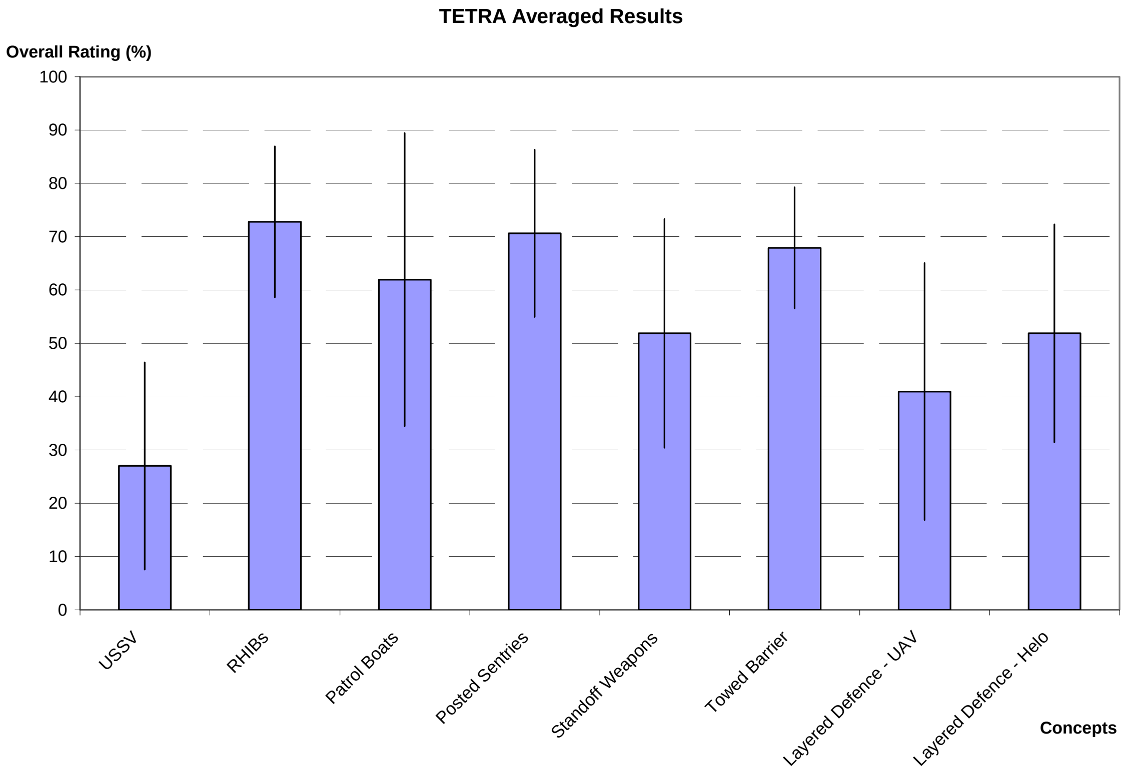



***Figure 13.*** *Tetra Results of Force Protection Concepts*

### 3.3 MARCUS Evaluation

An evaluation with MARCUS also took place at the workshop to determine the utility of this in-house methodology. MARCUS uses a different rating system in which participants are asked to “vote” for their favourite candidate, or in this case concept. Other concepts are voted from most to least preferable using a letter system of scoring, i.e. A for their most favourite candidate, B for the second favourite and so on. Ties are allowed between candidates or concepts. Participants were asked to log into a web-based system individually to cast their votes for each of the alternatives. The system itself can be utilized from any location in which web access can be gained. Due to the fact that the

controller was required to set up the scenario/alternatives in advance, it was not possible at the workshop to change the list of concepts (or criteria) to accommodate the additional concepts generated during the concept generation phase.

MARCUS determines the favourite candidate by minimizing the measure of agreement in the weighted average rankings across the criteria and finds the closet consensus point[4]. Other information on this method is available and a power point presentation is included in annex A. As a decision-making tool it has been used for setting budget priorities for defence research, for example[5].

Concepts according to MARCUS were ranked in order as follows:

1. Armed RHIBs, patrol boats; and posted sentries tied for 1st place;

2. Stand off Weapon Systems; and

3. Unmanned Sea Surface Vehicles.

As previously mentioned the other layered defence concepts generated at the workshop could not be evaluated within the time frame of the workshop. The results were computed manually by the Central Operational Research Team due to unforeseen difficulties (a hard drive failure). As a result no further report on the method or comparison of the results was available.

### 3.4 Group Consensus Results by Discussion

The results from using the three group decision-making approaches were obtained by survey of each of the preferences. In addition the participants came to a consensus of which concepts were favoured by means of a discussion. The concept considered to have the most merit was the layered defence concept consisting of armed RHIBs, posted sentries and patrol boats augmented by air support in the form of either UAVs or helicopters. These were considered as having the best likelihood of achieving a higher force protection capability.

It should be noted from the previous results that while the top ranking concepts included those that were part of a layered defence concept, the results from all the three ranking methods failed to show that the layered defence concept was the highest rated. The ranking methods did not reflect the apparent consensus from the group discussion. Feedback form the participants suggested that this was due to the use of equal weighting between the criteria. It was also suggested that performance should be weighted higher than the other criteria, giving more weight to performance than to cost, development, R&D and deployment ability, for example.

---

[4] For more information on this methodology the Central Operational Research Team (CORT) should be consulted at the Centre for Operational Research and Analysis (CORA) in Ottawa.
[5] Video conference Briefing from DG CORA CORT on previous applications using MARCUS

A sensitivity analysis was conducted on the Tetra results to determine the impact of different weightings. In addition to Case A shown in Figure 14 which used equal weightings, two other weighting schemes were arbitrarily used as shown in Table 1. The weighting scheme for Case B reduced the weight of the other criteria relative to performance. Case C reduces these further, in particular making cost 50% as important as performance. The other weights are noted in the table.

***Table 1.*** *Weighting Schemes*

| Criteria | Case A. Equal Weights | Case B. Different Weights (1) | Case C. Different Weights (2) |
|---|---|---|---|
| Overall Cost | 100% | 75% | 50% |
| Deployment | 100% | 90% | 25% |
| Technical Risk | 100% | 25% | 25% |
| Development | 100% | 50% | 25% |
| Performance | 100% | 100% | 100% |

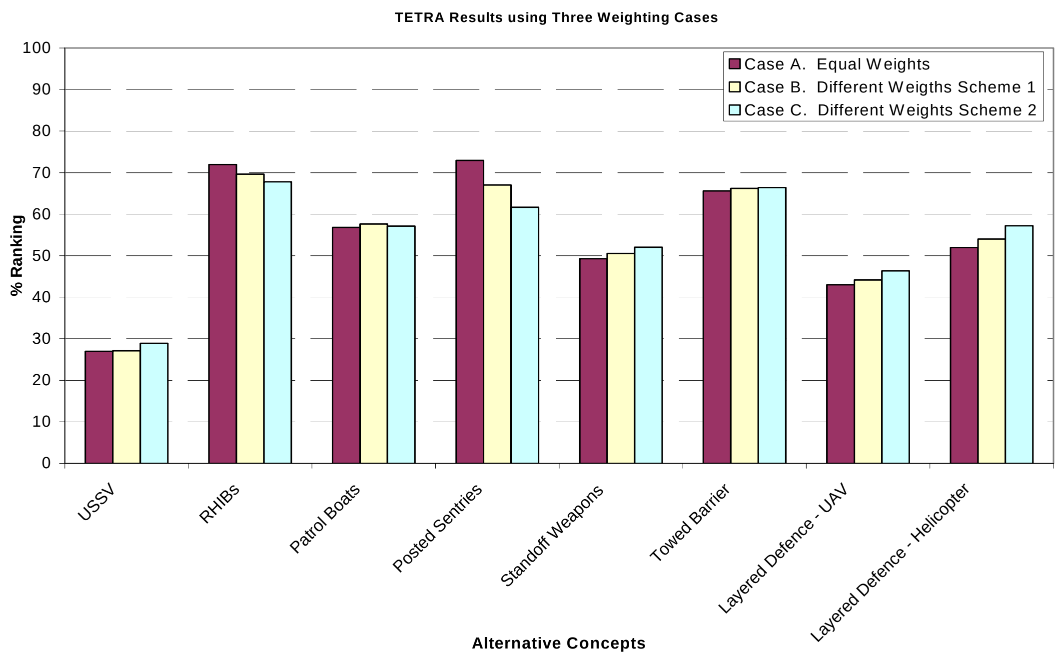



***Figure 14.*** *Tetra Results with Different Criteria Weighting Schemes*

## 3.5 CPF FP In-Harbour Transit Concept Selection

From the results of the three different group decision-making methodologies there was no single favoured concept. The group through discussion favoured a combination of concepts as depicted in Figure 15. It would require a detailed examination of each of the favoured concepts with an emphasis on modelling and simulation in order to determine their actual merit.

***Figure 15.*** *CPF Force Protection In-harbour Transit Concept Selection*

# 4. Summary and Conclusions

An investigation into the Maritime CD&E process was conducted by examination of a current issue facing the Canadian Forces. The approach made use of group decision making as one method for the generation of concepts and screening and selection of favourable alternatives. Three decision-making techniques were used to rank alternatives against generic criteria. The criteria used were overall cost, technical risk, development, deployment and finally performance.

A group workshop was held in which 6 proposed concepts were ranked using the group decision-making tools. The results of each of the method showed that there was no single alternative that ranked higher than others. The problem of implementation of a Maritime CD&E Capability at CFMWC to conduct projects in the 0-5 year time frame for the given scenario depicted is dependent upon the ability to generate, screen and select concepts.

Group consensus decision-making methodologies by themselves are not a panacea towards concept development but provide a starting point from which to proceed with more refinement of favourable solution alternatives. Due to the subjective nature of concept screening based on group consensus it is necessary to model, if possible, a range of favourable concepts or alternatives. However group decision-making is a useful approach for screening some concepts while keeping others.

The process of conducting CD&E by taking this group decision-making approach is one that may have more indirect benefits than direct results. The group discussion by itself during the workshop showed that the group and sub-groups were able to independently generate a layered defence concept and that this concept was by consensus the best alternative in the opinion of the group. The results of having a workshop in which participants are given the opportunity to focus on a particular problem and different solutions was perceived to be of great benefit in speeding up the process of deriving and implementing solutions.

Unfortunately this indirect benefit cannot be fully substantiated. One further comment is that the result of going through the CD&E process provided other indirect benefits. Using a focused workgroup on a particular current issue facing the CF stimulated discussion and indirectly prompted individuals and organizations to focus on this particular problem. This may be the greatest benefit in which CD&E can have a substantial impact.

# 5. References


1. Symposium Working Group, “Creating the CF of 2020- Concept Development and Experimentation and Modelling and Simulation”, DND Concept Paper on CD&E and M&S, November 1, 2000, Ottawa, Canada.

2. Hazen, M.G., Graham, A., Shurson, A., “Maritime Concept Development and Experimentation (CD&E): Options for Implementation”, Technical Report DRDC Atlantic TR 2003-066, March 2004.

3. Brown, T., and Hibberd, T., “The Role of Operations Research and Analysis in Concept-led Long-range Planning”, DSTO-CR-282, DSTO Information Sciences Laboratory, Australia, February 2003.

4. Minutes of the First Maritime CD&E WG, Held at CFMWC, 5-6 October, 2004, MS:3371-1150.

5. Gammon, M., Maritime Concept Development Operational Research Proposal, 3550-1 OR&A.

6. TTCP Guide for Understanding and Interpreting Defence Experimentation TTCP GUIDEx, TTCP JSA AG-12, January 2005.

7. Army Experimental Framework (AEF) - Experiment Handbook, Australian Army Publication, Advance, Edition 1 Advance Issue, January 2005.

8. Saunders, P.H., Smith, P., Vasiliev, B., “Analysis of Force Protection and Waterfront Exclusion Zones in HMC Dockyard”, MARLANT ORD Research Note RN-03/2001, November 2001.

9. Saunders, P.H. and Billyard, A.P., “Effectiveness of Force Protective Measures: Phase I – Land Attack”, MARLANT OR Project Report PR-02/2003, March 2003.

10. Billyard, A.P., Saunders, P.H., Carson, N.L., “Effectiveness of Force Protection Measures: Phase III Sub-surface Attack”, MARLANT ORD Project Report PR-02/2004, September 2004.

11. Crawford, M.G.A., “Current Canadian Capabilities versus Small Boat Swarms: Preliminary Results”, MARLANT ORD Research Note RN-01/2003, July 2003.

12. Saunders, P.H. and Crawford, M.G.A., “Effectiveness of Force Protection Measures: Phase II – Surface Attack”, MARLANT ORD Project Report PR-03/2003, October 2003.

13. Crawford, M.G.A., “Capabilities and Tactics versus Small Boat Swarms”, MARLANT Project Report PR-01/2004, June 2004.

14. Kudo,R. and Terano, T., “Automating Concept Development by Analogical Reasoning for Advanced Decision Aids”, Expert systems with applications, Vol 10, No. ¾, pp. 357-364, 1996.

15. Maritime Command Orders (Draft) – Maritime Command Concept Development and Experimenation Policy, To Be Published, DGMED/MRCC.

16. B. T. Waruszynski, “Enabling Collaborative Capability through Virtual Teamwork… the Way Ahead”, Technical Memorandum DRDC Ottawa, TM 2003-217, December, 2003.

17. B. T. Waruszynski, “Work Team Strategies ”, Technical Memorandum DRDC Ottawa, TM 2004-225, December, 2004.

18. http://www.dodsbir.net/sitis/view_pdf.asp?id=N051-055.pdf

19. Zhang, Q, Chen, J.C.H., Chong, P.P., “Decision Consolidation: Criteria Weight Determination using Multiple Preference Formats”, Decision Support Systems, Vol. 38, 2004, pp. 247-258.

20. Lin, C. and Hsieh, P., “A Fuzzy Decision Support System for Strategic Portfolio Management”, Decision Support Systems, Vol. 38, 2004, 383-398.

21. Barzilai, J., “Measurement and Preference Function Modelling”, International Transactions in Operational Research”, 2005, 175-183.

22. http://www.fas.org/man/dod-101/sys/ship/weaps/mk-38.htm

23. http://www.army-technology.com/projects/eryx/

24. Adamsson, J. and Asiedu,Y. “The Maritime Vignette (MARVIN) Simulation”, ORD Research Note RN 2003/08, August 2003.

25. Canadian Forces Maritime Warfare Centre, Information Paper, Joint Semi-automated Force (JSAF), Maritime Synthetic Coordination Office.

# Annex A. TETRA Quick Start Guide

The following is a quick start guide for using Tetra. When operating from the CD, double clicking on the guide will open as a PDF document. While a user guide only, the examples provide some insight into how TETRA can be used.

## TETRA QUICKSTART GUIDE

Tetra



Version 1.1

**PURPOSE:** **Select the best option using Preference Function Modeling, PFM©**

**SCOPE:** Evaluate 2 or more choices
Employ 1 or more criteria
Preference inputs by 1 or more evaluators

**STEPS:**

1. Identify all feasible alternatives for the decision at hand.
2. Define all relevant criteria (and subcriteria if necessary, using a hierarchy) to be used to evaluate the alternatives.
3. Allocate a weight to each criterion based on its relative importance. (Note: for some decisions, steps 2 and 3 are completed before step 1).
4. For each criterion, define the Bottom (score=0) and Top (score=100) reference alternatives.
5. Rate all of the alternatives against each criterion.
6. Run the model, yielding a total score for each alternative, with the highest score corresponding to the best choice.

**EXAMPLE: Buying a house**

**STEP 1 – IDENTIFY ALTERNATIVES:** Suppose you have narrowed the choice to 5 acceptable homes: a bungalow, a split-level, a 2-storey house, a townhouse and a condominium.

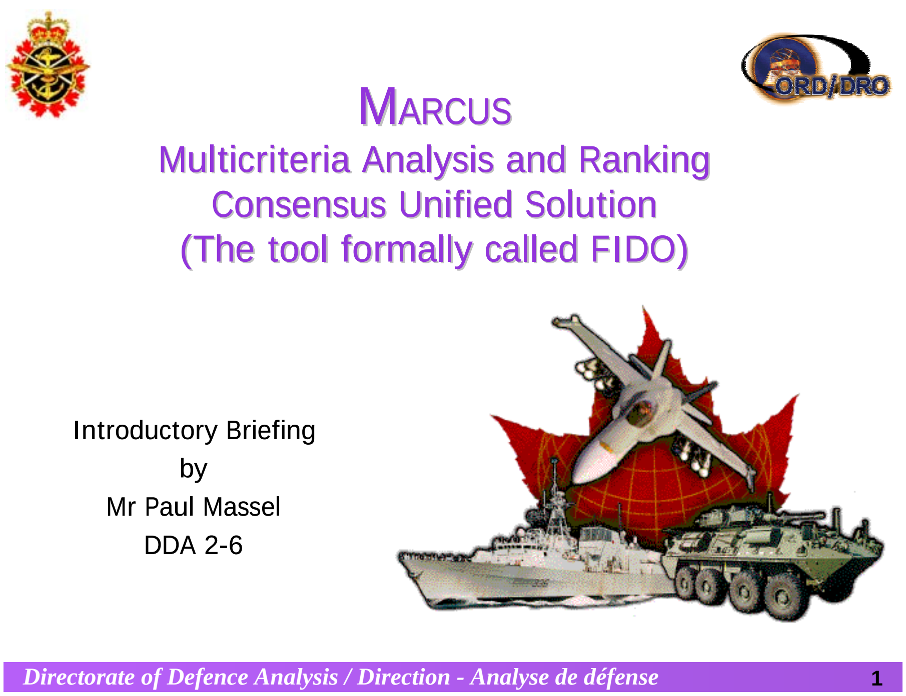
*TETRA actions* to create *alternatives*:

- **OPEN** TETRA.
- **CLICK** on the *New Model* icon, then enter a suitable name for your model, such as "House Purchase."


- 1 -

# Annex B. MARCUS Presentation

The following form part of a presentation on MARCUS. More information on the methodology can be obtained from the Centre of Operational Analysis –Central Operational Research Team, at National Defence Headquarters, in Ottawa.



## MARCUS - General Description

- Multi-Criteria, Multi-Participant Decision Support Tool
- Both a Framing Process and a Software Application
- MARCUS Output (Prioritised List) Provides Departure Point for Analysis and Discussion, NOT a Definitive Answer
- Vehicle for Promoting Strategic Dialogue and Developing Better Alternatives

*Directorate of Defence Analysis / Direction - Analyse de défense* 2

## The MARCUS Process - Decision Framing Process

- "Value-Focused Thinking"
- Define Objectives
- Define Ranking Criteria and Criteria Weights
- Select Options
- Describe Context and Select Voters

*Directorate of Defence Analysis / Direction - Analyse de défense* 3

## The MARCUS Process - Prioritisation Process

- Individually Rank Options against Criteria
- Determine Overall Consensus Ranking using Operational Research Division (ORD) Developed Ranking Algorithm
- Discuss Overall Consensus Ranking, and Revote if Desired
  - Examine voter consensus (Schools of Thought/Clustering)
  - Attempt to achieve better alternatives, greater consensus
- Adjust as required to cater for Programmatic Considerations

*Directorate of Defence Analysis / Direction - Analyse de défense* 4

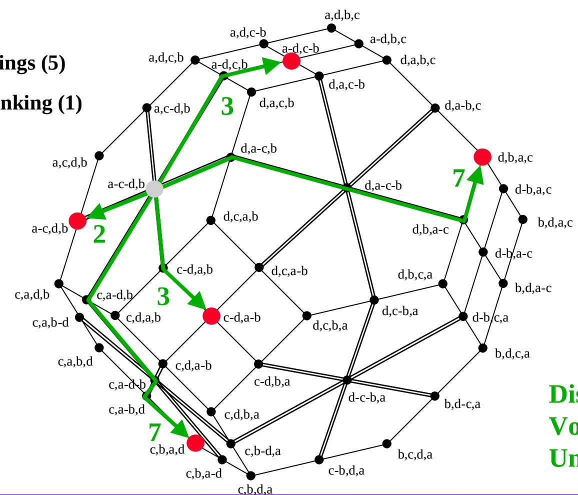
## MCDA – Rank Consensus

- The ORD algorithm is not a pair wise comparison. Rather it minimizes the measure of agreement in the weighted average rankings across a given number of criteria. It finds the closest consensus point or points in a matrixed collection of ranked votes

*Directorate of Defence Analysis / Direction - Analyse de défense* 5

## It is not linear but rather an N dimensional solution.

- Input Rankings (5)
- Solution Ranking (1)
  **a-c-d, b**




**Distance = Voter Unhappiness**

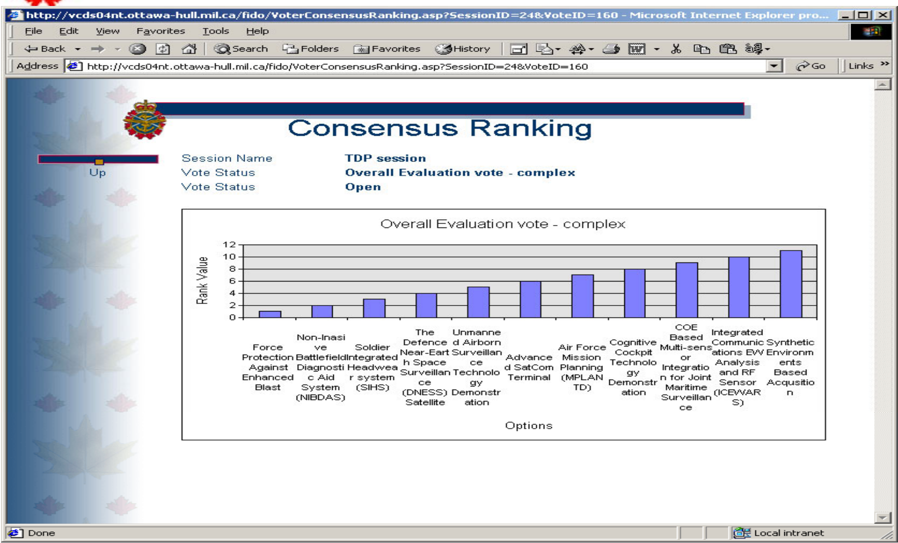
*Directorate of Defence Analysis / Direction - Analyse de défense* **6**

## MARCUS Tools

- FIDO v1.0 - MS Excel prototype
- FIDO v3.0:
  - A web-based, database connected application
  - Incorporates 3 ranking algorithms
  - Accessible from the DWAN
  - Final stages of validation
- Has been used by
  - The Army Transformation WG & The Asymetric Threat WG
  - DRDC TDP & CAS/DRDC TIF/TIA prioritisation

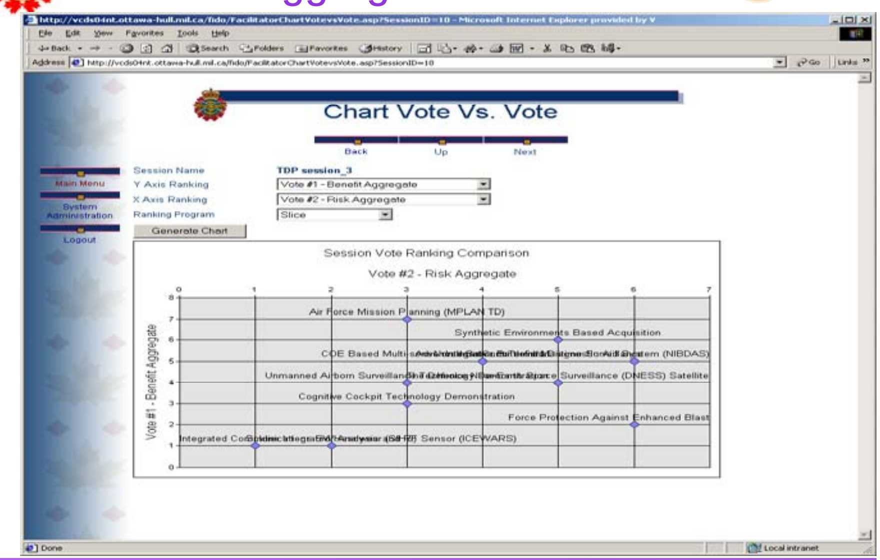
*Directorate of Defence Analysis / Direction - Analyse de défense* **7**

## Determined Consensus Ranking



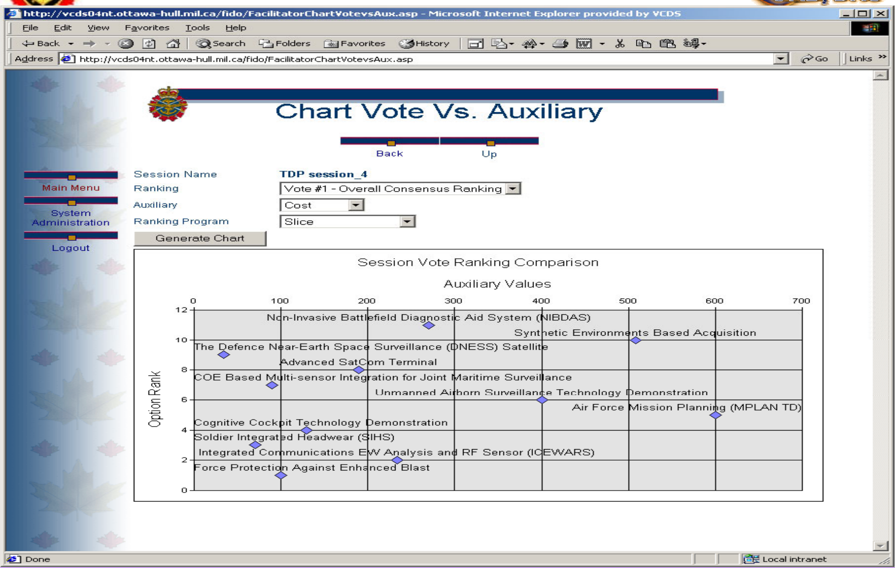

*Directorate of Defence Analysis / Direction - Analyse de défense* **8**

## Aggregate Benefit vs. Aggregate Risk




*Directorate of Defence Analysis / Direction - Analyse de défense* **9**

## Consensus Ranking vs. Cost




*Directorate of Defence Analysis / Direction - Analyse de défense* **10**

## Conclusion

- MARCUS
  - Is a Decision Support Tool
  - Involves a two step process:
    - Decision Framing Process
    - Prioitisation Process
  - Useful for:
    - group consensus building
    - making explicit the implicit
    - trade-off and alternative option studies

*Directorate of Defence Analysis / Direction - Analyse de défense* **11**

This page intentionally left blank.

# Distribution list

Internal Distribution

6 - DRDC Atlantic Library

2 - M.A. Gammon (Author)  1 CD & 1 Hard Copy

External Distribution

2 - CO CFMWC, CFB Stadacona

1 - NDHQ/CORA/DOR (Joint) - B. Dickinson

1- NDHQ/CORA/CORT  - P. Massel

1 - NDHQ/CORA/Library

3 - NDHQ/MRCC - Cdr. M. Tunnicliffe

1- MARLANT/N02OR - P. Saunders

1- NDHQ/ ADMS&T/ DRDKIM

This page intentionally left blank.

## DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.)

DRDC Atlantic
9 Grove Street, PO Box 1012
Dartmouth, NS B2Y 3Z7

2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable).

UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title).

Maritime Concept Development Approach for a Force Protection In-Harbour Transit of a Canadian Patrol Frigate

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

Gammon, Mark A.

5. DATE OF PUBLICATION (month and year of publication of document)

September 2005

6a. NO. OF PAGES (total containing information Include Annexes, Appendices, etc).

42

6b. NO. OF REFS (total cited in document)

25

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered).

Technical Memorandum

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include address).

Canadian Forces Maritime Warfare Centre

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant).

X-20db

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written).

10a ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DRDC Atlantic TM 2005-148

10b OTHER DOCUMENT NOs. (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

( X ) Unlimited distribution
(   ) Defence departments and defence contractors; further distribution only as approved
(   ) Defence departments and Canadian defence contractors; further distribution only as approved
(   ) Government departments and agencies; further distribution only as approved
(   ) Defence departments; further distribution only as approved
(   ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected).

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual).

Maritime Concept Development and Experimentation (CD&E) is being implemented to facilitate development of innovative concepts and rapid prototyping of solutions to advance maritime capabilities and fill capability gaps. Concept development is applied to the problem of an in-harbour transit scenario for a Canadian Patrol Frigate (CPF). The objective is to explore the CD&E process through the use of a current issue. The scenario represents a hypothetical ship deployment versus an asymmetric threat of a small craft surface terrorist attack. The nature of the threat means that unconventional solutions are required. As an initial approach, the use of group decision-making methodologies is tested for generating and screening concepts. The lessons learned provide initial observations of the CD&E process as well as insights for this scenario.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title).

Concept Development, maritime force protection, modelling and simulation, group consensus decision making.

This page intentionally left blank.

## Defence R&D Canada

Canada's leader in defence
and National Security
Science and Technology

## R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE DÉFENSE

www.drdc-rddc.gc.ca